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Online Tools for the Creation of Personal Learning Environments in Engineering Studies for Sustainable Learning

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Abstract: This work describes an educational experience in which personal learning environments (PLEs) were created as a tool for the acquisition of subject contents in the science, technology, engineering, and mathematics (STEM) areas. For this, the same methodology was developed for different subjects in order to teach the use of some digital tools, learn about the concepts related to the PLE, and apply the PLE to educational content promoting sustainable learning. Two questionnaires were designed to obtain information about the tools, activities, and subjects. The results of the questionnaires were analyzed using the Kaiser–Meyer–Olkin test and Pearson's correlation. Then, several factors and the relationships between them were defined. In addition, this paper shows that because the PLE is based on a learning model in which the learner is the protagonist, its use is linked to sustainable learning. Therefore, the use of PLEs allows the development of the competences of "collaborative work" and "information management and organization", which are both related to sustainable learning. In addition, the use of PLEs promotes understanding of the subjects and academic results in the subjects.

Keywords: information and communication technologies; ICTs; personal learning environment; PLE; online tools; sustainability learning; STEM areas

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1. Introduction

Nowadays, achieving sustainable development is a key objective in which education has a strategic role. Education is a decisive factor for human development because of its political, social, and cultural impact. This factor could influence the current development model and redirect it towards sustainability [1].

Sustainable learning and education are a philosophy of aspiration for learning and teaching based on principles of sustainability. Education for sustainability reflects concerns about educating people in different skills related to the understanding of what is happening (knowledge), integration into the society in which they live (learning to be) and knowing how to participate (learning to do) to enable a more sustainable and fair society for all. Moreover, education for sustainability must provide the ability and capacity to learn how to learn. In this way, sustainable lifestyle patterns can be incorporated and changes can be produced. For these reasons, the idea of sustainable learning, in which the protagonist is the one who learns, is emerging [2,3].

On the other hand, learning should not be limited to the individual sphere; rather, the capacity to collaborate with others must be developed in order to achieve changes in institutions and social structures. Sustainable learning must, therefore, promote the personal and group search for organizational guidelines in an effort to make progress towards sustainability [3–5].

To achieve this, an innovative approach focused on the participation and involvement of students in their own learning process must be promoted.

As a response to the calls of international institutions and organizations, special attention has been given to sustainability in education. In recent years, the interest in this topic and its inclusion in curricula at different educational levels has grown, especially in teacher training [6,7]. In fact, there is a growing trend of the presence of contributions to education for sustainability in conferences, congresses, and educational journals [2].

However, it is necessary to add tools that promote collaborative work and the ability to learn how to learn. For these purposes, information and communication technologies (ICTs) are suitable, especially in areas related to science, technology, engineering, and mathematics—the so-called "STEM" areas. In recent years, ICTs have led to new, more flexible, and open training configurations. In this context, the relevance of the Blended Learning concept (b-learning) has been promoted [8]. Fernandes et al. (2016) [9] conducted extensive research on this topic, and they defined b-learning as a "mixed learning paradigm that integrates e-learning with traditional learning theories and practices, materialized in a flexible, multimodal, and multilinear redesign that promotes self-regulation and collaborativeness." This methodology combines face-to-face training with online learning experiences, allowing students to reduce their classroom time and to evaluate the work done outside the classroom [10–12]. Suitable ICT tools are necessary to carry out b-learning. This type of learning is carried out not only on traditional devices, but also on mobile devices by means of suitable apps. In this case, the experiences are called "mobile learning" or "m-learning". This teaching and learning methodology is based on the use of small electronic devices with wireless connectivity, such as smartphones or tablets. In addition, these types of devices, which students regularly use in their daily lives, have features to improve conventional learning [13].

One of the main characteristics of this learning model is its spatial and temporal availability. The aim is to improve learning in any place and at any time because the access is remote and not limited to a traditional classroom. Therefore, it is a methodology that allows flexible learning. In addition, it favors self-learning by students, allowing them to carry out interactive tracking of what they have learned in the classroom. Smart devices ensure access to information in an uninterrupted and easy way, which increases the motivation and interest of the students.

Today, all of the Web 2.0 tools allow users to apply ICTs to engineering training in order to organize and distribute content, thus enabling adaptation of the learning process to suit the needs of particular users. In this way, student-centered learning is favored and encouraged. In this context, personal learning environments (PLEs) have arisen as Web 2.0 tools for accessing, building, managing, and sharing educational content and satisfying students' learning needs. In the field of educational technology, the creation of a PLE can be understood as "the set of tools, information sources, connections, and activities that each person uses frequently to learn" [14,15]. Some authors consider PLEs as technological tools that aim to develop the best learning platform. Other authors, however, consider PLEs as a pedagogical idea of how to learn with technology [16]. However, there is consensus on considering PLEs as a techno-pedagogical tool [14]. Consequently, PLEs encompass tools, services, and available content that are targeted toward students during their learning process both outside and inside the classroom. For those reasons, PLEs can be very useful in all of the STEM areas, and particularly in engineering education, which requires lifelong learning [17].

2. ICT Experiences in STEM: PLEs as Tools for Learning

Twenty-first century skills are the abilities that today's students need to master in their careers. Students need to know how to use digital technologies for learning and solving problems. In recent years, PLEs have been considered a promising tool as they incorporate

ICTs into learning in an organized manner [18]. Recent studies have analyzed the tools for PLE development versus traditional tools, such as blackboards, used in the teaching–learning process. How digital tools influence students' perceptions and the development of their critical thinking capacity in relation to a subject was also evaluated [19].

PLEs enable lifelong learning and help the acquisition of competences during all life stages (educational, professional, etc.). ICT experts consider that Web 2.0 has changed not only the technologies available on the Web but also the way in which people communicate and relate to each other. This has led to the ubiquity of access to the Web and the variety of devices that allow us to interact with it. Students today can choose the tools and services that best suit their needs. This is a means of customizing their learning experience [20].

There are some experiences of collaborative knowledge-building using PLEs supported by Web 2.0 tools [21]. Both Web 2.0 and social media modify the traditional roles of the university as an institution, the teachers, and the students, advocating a b-learning or m-learning approach that, as mentioned, makes learning more flexible in space and time [22]. From the student's point of view, the use of ICT in university teaching offers opportunities to motivate both learning and collaborative skills [23]. Web-based collaborative learning environments are often used to support classroom teaching activities and motivate students to do their homework and attend classes in higher education. All these environments allow users to manage their learning according to their own personal preferences. In addition, they promote socialization and collaboration with their social networks that offer them easy social interaction.

In this context, there are experiences focused on the use of the email, social networks, file sharing, video sharing, internet searches, and online encyclopedias, which are the most widely used applications for PLEs. In addition, some studies highlight the sociological importance of the use of new tools as PLEs, even though they also require a process of social adaptation of the users. It is even claimed that a PLE is a framework of reference that can help us to understand citizens' social adaptation processes and influence the sustainability of local and global systems [24].

There are experiences of PLE development in different areas [25]. In primary school, there are experiences based on the use of mobile technologies in the students' PLEs. These experiences are focused on promoting integration in school and intercultural competencies [26–28].

In secondary education, the emphasis is on student control over the entire learning process, including building a learning environment. The results of the experience suggest that the model can improve student participation in the construction of their learning environments by influencing communication between the teacher and the students. The experiences also involve students in the use of tools, resources, and their learning environment, improving their sense of ownership over their learning environment [29].

At the university level, there are also experiences in several fields. In particular, in degree studies relating to early childhood education and primary education, the use of electronic devices (laptops, smartphones, etc.) for PLE development is highly valued. In addition, the experiences also value how PLEs promote personal development and the shaping of professional careers, since they are customizable, interactive, and useful tools to produce, edit, and publish information [30].

A study was carried out involving students in degree studies of computer science applied to education, which showed the increasing number of courses that are based on virtual classrooms and that promote learning using PLEs [31].

Other studies in the STEM areas, focused on engineering, showed that PLEs place students in a central position in the learning process, allowing them to design their own learning environments. Students' insights after these experiences indicate that the building and use of a PLE is a difficult task that requires a specific teacher and pedagogical support. The results of the studies highlight that the design of a PLE requires both ICT skills and solid knowledge of learning methods [32]. As can be seen, the use of ICT and mobile learning to support the development of a PLE is quite widespread, although its success may depend on factors such as student skills, teacher training, technology availability, and compatibility with the subject's contents [33].

In addition, we should bear in mind that in the STEM field, the practical part of the subjects has a fundamental role in the curriculum of any scientist, technician, engineer, or mathematician. The practical part of the subjects helps students face the real world and put into practice what they have learned. From this point of view, there are experiences in which tools like a learning management system (LMS), e-portfolio, and remote laboratory management system (RLMS) are used to implement a PLE for the practical sessions of a subject. In these experiences, PLEs are educational platforms that help students take control and manage their own learning process, achieving a specific objective [34]. The PLEs are not considered strictly as educational platforms, but they are based on the socio-constructivist learning model in which the learner is the protagonist of their own learning, cooperating and collaborating with the group to build new knowledge. They emerge as one more phenomenon of Web 2.0, in which users are creators as well as consumers of information [35]. The PLEs consist of a template, which can be customized, and a set of "social software tools" that allow participants to (i) create their own learning environment; (ii) collaboratively create and publish content, for example, wikis, weblogs, and podcasting; (iii) integrate, store, classify, and index multiple sources of information and data, for example, Flickr and YouTube; (iv) communicate instantly and in multimedia, e.g., via Skype, AIM, and ICQ; and (v) create their own communities (MySpace, Facebook, and LinkedIn), for example, Symbaloo and Netvibes. The learning content management system (LCMS) is a multiuser environment where learning developers can create, store, reuse, manage, and deliver digital learning content from a central object repository [36]. An LCMS is an application which facilitates the creation, management, and transfer or distribution of learning contents [37]. It can be considered an e-learning platform with more specific functions, being a software application that combines the course management capabilities of an LMS (learning management system) with the storage and content creation capabilities of an MSC (management system of contents). An LCMS provides content management but is oriented towards e-learning and generally integrating standards for the production of reusable educational contents [38]. These systems can be integrated into an LMS, providing, in addition to an authoring system, a repository of learning objects that the teachers can use and reuse for their courses in the LMS [36].

In view of the above, the objective of this paper was to show the experience in different subjects related to engineering in which ICTs are used for the building of a PLE. The aim was to verify the effect that the digital tools have on the development of the subjects and check whether they improve the teaching–learning process. In addition, the influence of PLE development on achieving competences related to sustainable learning, such as collaborative work and information management and organization, was evaluated.

3. Methodology

This paper describes the experience of the implementation of PLEs developed by teachers of technological areas at the University of Jaen. Concepts related to PLEs were used in different subjects within the framework of a teaching innovation project (PID55_201617).

This experience was focused on the use of some tools for the implementation of the PLEs. The activities were focused on different steps of PLE creation: searching, information management and organization, information processing, and sharing. In addition, the experience was developed to improve the acquisition of skills in "collaborative work" and "information management and organization", both skills involved with sustainable learning.

The students who participated in this experience were attending different courses in electronic engineering degree studies, one of which was a fourth-year course in "Power Electronics" and another was a fourth-year optional course in "Data Acquisition Systems". Moreover, a first-year subject, "Electronic Systems and Industrial Instrumentation", of industrial engineer master's studies was also involved in the experience.

The methodology that was carried out in this work is described below. First of all, the activities methodology used by the teachers is shown. Next, the methodology used to evaluate the experience is presented; two questionnaires were used. Also, we describe the statistical method used to group the questions into factors and evaluate the relationships between them. Finally, the academic results of the subjects are analyzed.

3.1. Activities

The proposed methodology for building a PLE was aimed to evaluate the learning results achieved at the end of the learning process, related to the specific technical topics included in the different subjects involved in this teaching innovation project. In addition, PLEs were also evaluated in order to analyze whether there was a positive impact on the acquisition of skills and competences. As there should be a clear relationship between the activities, evaluation, and the learning outcomes, the methodology can be described in four steps (Figure 1).

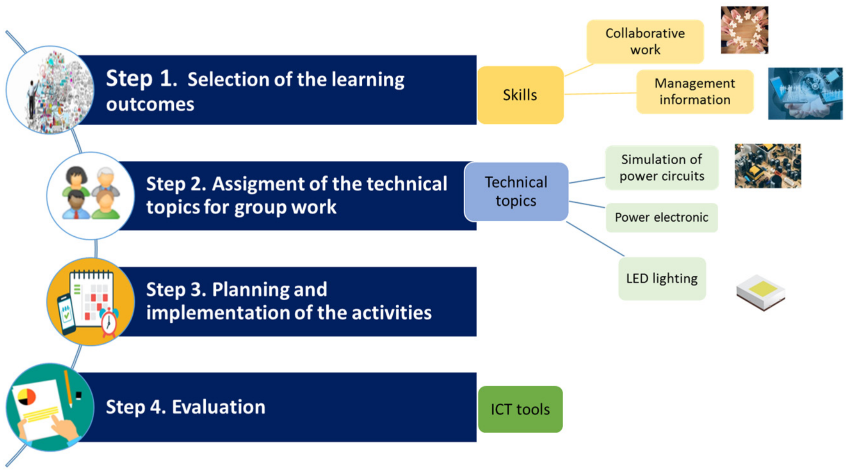

Figure 1. Methodology.

Step 1. Selection of the learning outcomes.

The first step was the selection of the learning outcomes of each subject (a description of what is expected of the students in terms of knowledge and skills when the learning process is finished). Specific learning outcomes related to technical topics of the subjects were selected, including the learning outcome of "encouraging collaborative work and information management", which was applicable to all the subjects involved in this experience.

Step 2. Assignment of technical topics for group work (*).

Working groups of 3–5 students to develop the activities in each subject were created. Each group chose a technical topic. The activities were required to deal with the chosen technical topic to achieve the learning outcomes.

* Examples of some of the technical topics:

- History, evolution, and future of power electronics (semiconductors, applications);
- Electronic power converters in electric traction;
- Switching regulator converters;
- Electronics power converters: inverters, applications;
- AC regulators and static switches for LED lighting control: LED drivers;
- LED lighting in automotive applications;
- Power electronics and renewable energy;
- Power electronics and smart grids;
- Simulation of power circuits and online manufacturer tools;
- Sensors;
- Signal conditioning.

Step 3. Planning and implementation of the activities.

The activities were focused on the different steps of PLE creation. The concepts, structure, and necessary tools for the creation of a PLE were initially explained in a seminar.

Figure 2 shows the ICT tools recommended by the teachers. They are suitable for building a PLE since they facilitate online collaborative work among students and allow teachers to monitor and evaluate the activities.

Figure 2. ICT tools.

A PLE could be built using social networks, office packages, or other generic software. However, there are online tools which may promote the design of a PLE, such as Symbaloo, Ning, Gnoss, Netvibes, etc. Previous works [39,40] have found that Symbaloo could be the most suitable tool because it is free for basic users, easy to handle, and intuitive, and it can also be integrated with other tools [41]. Symbaloo is a bookmarking tool with which resources and links are managed on a website called a "Webmix". A Webmix has a grid layout with a central box and collection of squares, called tiles. Each tile may have a specific content: a URL, a news feed, a widget (calculator, weather, etc.), or a pdf file or video. Tiles can be easily grouped according to topic using different colors.

For these reasons, students should build two Webmixes with Symbaloo, one of them collaboratively and another one individually. In this exercise, all of them must be related to the chosen technical topic. Figure 3 shows an example of a Webmix related to a technical topic.

Figure 3. Example of a Webmix of the subject "Power Electronics".

The Webmixes built by the students must be shared with their classmates on a chosen social network. Comments, suggestions, and constructive criticisms on the technical topics should be edited and shared not only among students, but also with the teachers. Thus, there is an online path and collaborative work between the different working groups and teachers. Moreover, work progress in tasks (individual and working group) may be analyzed and shared. A collaborative learning network may be created by students and teachers. Finally, a final report should be elaborated by each group with a collaborative tool for the editing of documents in real time, such as Google Docs.

Step 4. Evaluation system.

The three subjects involved in the project used the same rubric. The activities were evaluated by taking into account both the individual and collaborative work of each student.

Mark: 0.25 A + 0.25 B + 0.25 C + 0.25 D, where

- ➢ A: Quality of the materials on the proposed technical topics which were elaborated by students: contributions, analysis, and comments of each one.
- ➢ B: Knowledge and use of the tools for PLE creation.
- ➢ C: Active participation and interaction in their own working group and with other groups.
- ➢ D: Final report of PLE activities: a description of the creation process of the PLEs from the beginning with a detailed explanation of the steps.

However, the weights of the activities in the final evaluations of the subjects were different. For the subject "Data Acquisition Systems", it represented 5% of the mark; for the subject "Electronic Systems and Industrial Instrumentation", it was 7% of the mark; and for the subject "Power Electronics", it was 15%.

3.2. Questionnaires

To evaluate the experience, two questionnaires were developed. One of them was related to the tools used (Questionnaire A, Appendix A), and the other one evaluated the experience and the acquisition of competences (Questionnaire B, Appendix B).

3.3. Statistical Study of the Results and Factor Analysis

The statistical results of the questionnaires were calculated using IMB SPSS Statistics software version 25 and Microsoft Excel 2013. On the results of the questionnaire related to the experience (Appendix B), the Alpha Reliability Test was used to verify the internal consistency of the test. The Cronbach's alpha values were obtained, indicating that the test was consistent. For factor analysis, the Kaiser–Meyer–Olkin (KMO) test was used, with a statistical level greater than 0.6 deemed as acceptable, and using the explained variance of each factor [42].

Table 1 shows the descriptive statistics and the variables of each factor, which correspond to each of the questions in Questionnaire B (Appendix B).

Table 1. Descriptive statistics and factors obtained from the variables in the questionnaire questions.

	Descriptive Statistics			Factor
	Variable	**Mean**	**Deviation**	
V1	Communication	3.99	1.094	Purpose of Internet Access (PIA)
V2	Information	4.40	0.889	
V3	Work	3.93	1.020	
V4	Leisure	4.16	1.024	
V5	Organization	2.99	1.161	
V6	Training	3.82	0.968	
V7	Social relationships	3.64	1.276	

Table 1. *Cont.*

	Descriptive Statistics			Factor
	Variable	**Mean**	**Deviation**	
V1	Folders	4.45	0.867	Information Management and Organization (IMO)
V2	Social bookmarks	1.61	1.416	
V3	Wikis/Blogs	1.67	1.462	
V4	Social networking tools	2.12	1.577	
V1	Friends	4.14	0.896	Information Credibility (IC)
V2	Social networks	4.16	0.851	
V3	Google position	4.06	0.968	
V4	Twitter trending topic	3.57	1.182	
V5	Presence in several resources	4.14	0.896	
V6	Expert recommendation	4.16	0.851	
V1	Sharing	4.14	0.896	Collaborative Work (CW)
V2	Interaction	4.16	0.851	
V3	Working together	4.06	0.968	
V4	Dividing the work	3.57	1.182	
V1	Symbaloo	3.43	1.323	Utility of the Tools (UT)
V2	GooglePlus	2.68	1.539	
V3	Feedly	1.81	1.115	
V4	Scoop.it	2.57	1.230	
V5	Diigo	2.36	1.403	
V6	Google Drive	4.22	1.136	
V1	Teacher's implication	3.72	1.1230	Activities (AC)
V2	Instructions	3.45	1.2070	
V3	Time spent	3.11	1.2070	
V4	PLE and learning	2.85	1.3314	
V5	Activities valuation	3.33	1.3467	
V6	Similar activities	3.13	1.4133	
V7	Effort vs. activity punctuation (marks)	3.60	1.2858	
V8	Collaborative work motivation	3.68	1.1818	
V1	Effort vs. subject results	3.47	1.2673	Subject (SB)
V2	PLE and subject contents	3.68	1.1439	
V3	PLE and digital skills	3.36	1.2123	
V4	Professional skills	3.47	1.2788	

Table 2 shows the values obtained in the Kaiser–Meyer–Olkin (KMO) test, which indicated whether it was appropriate to group the variables or not.

Table 2. KMO and Bartlett's test results.

		PIA	IMO	IC	CW	UT	AC and SB
Kaiser–Meyer–Olkin (KMO)		0.752	0.601	0.679	0.660	0.753	0.907
Variance (%)		71.215	65.410	68.954	65.413	72.341	74.032
Bartlett's test of sphericity	Chi-square approximation	191.832	16.152	91.881	35.238	59.651	778.108
	Degrees of freedom	21	8	15	6	15	66
	Significance	0.000	0.13	0.000	0.000	0.000	0.000

A KMO value equal to or greater than 0.6 and a variance equal to or greater than 60% indicates when variables are a factor.

Initially the variables related to the activities and the subject were considered together as one factor, but the method indicated that they were two factors. Therefore, there were seven factors: Purpose of Internet Access (PIA), Information Management and Organization (IMO), Information Credibility (IC), Collaborative Work (CW), Utility of the Tools (UT), Activities (AC), and Subject (SUB). Table 3 shows the values obtained from these factors.

Table 3. Values obtained from the factors.

Factor	Mean	Deviation
PIA	3.85	1.061
IMO	3.12	1.043
IC	4.04	0.940
CW	3.98	0.602
UT	2.88	0.714
AC	3.59	0.982
SUB	3.28	1.109

To assess the experience, the relationships between the factors were checked using the Pearson's linear correlation method (bivariate correlations).

4. Results

The results of this work are shown from different points of view, all geared towards sustainable learning. Moreover, the tools that the students used and their contributions to the subjects were valued. Through factor analysis, the correlations between the factors defined by the questionnaires were evaluated. At the end of this section, the academic results are also shown.

4.1. Sample Data

A total of 69 students participated in the experience. Of the total sample, 38.6% were students of Electronic Systems and Industrial Instrumentation, 40% were students of Power Electronics, and 21.4% were students of Data Acquisition Systems. Regarding gender, 85.2% were men and the rest were women.

The teachers involved in this experience were from two departments of the University of Jaen: The Department of Electronics and Automatics Engineering and the Department of Chemical Environmental and Materials Engineering.

4.2. Analysis of the Questionnaires

The results obtained from Questionnaire A, related to the tools (Appendix A), are shown in Table 4 and Figure 2.

Table 4. Results of Questionnaire A.

Uses	Symbaloo	Google Plus	Feedly	Scoop.it	Diigo	Google Drive
Search/find information	7.14	13.94	26.73	18.18	12.12	11.31
Obtain more detailed information	5.84	10.91	16.83	19.48	13.13	7.74
Information management	40.9	6.06	27.73	24.68	40.4	29.17
Publish information	12.99	27.27	5.94	17.53	9.09	11.31
Share information	27.27	30.3	11.88	11.04	22.22	33.93
Help students understand the subject and clarify doubts	5.80	11.52	10.89	9.09	3.03	6.55

The results indicate that all the tools were useful for the uses included in the questionnaire, although in different percentages. It was appreciated that the tools are very comprehensive, operational, versatile, and trustworthy. Their uses can be multiple and varied, depending on the users. However, for each tool, the users highlighted one or two uses over the others. For Symbaloo and Diigo, the students emphasized their role in "information management". In the case of the social network Google Plus, the students highlighted the uses "publish information" and "share information". Feedly also had two main uses identified by the students: "search/find information" and ""information management". Finally, Google Drive was highlighted for the uses "information management" and "share information".

Considering the deviation of the scores per application, Scoop.it had the lowest deviation, which would indicate that it may be a balanced tool in terms of the different utilities, not clearly excelling in one, but being valid for all. The other extremes were Symbaloo and Diigo, which had the highest deviations because they have some functionalities that stand out a lot over the others.

The disaggregated survey results were used to identify the usefulness of the tools (Table 4 and Figure 4). Overall, the uses were for information management (28.15%), to share information (22.77%), to search/find information (14.9%), to publish information (14.02%), to obtain more detailed information (12.32%), and to help the students understand the subject and clarify doubts (7.81%).

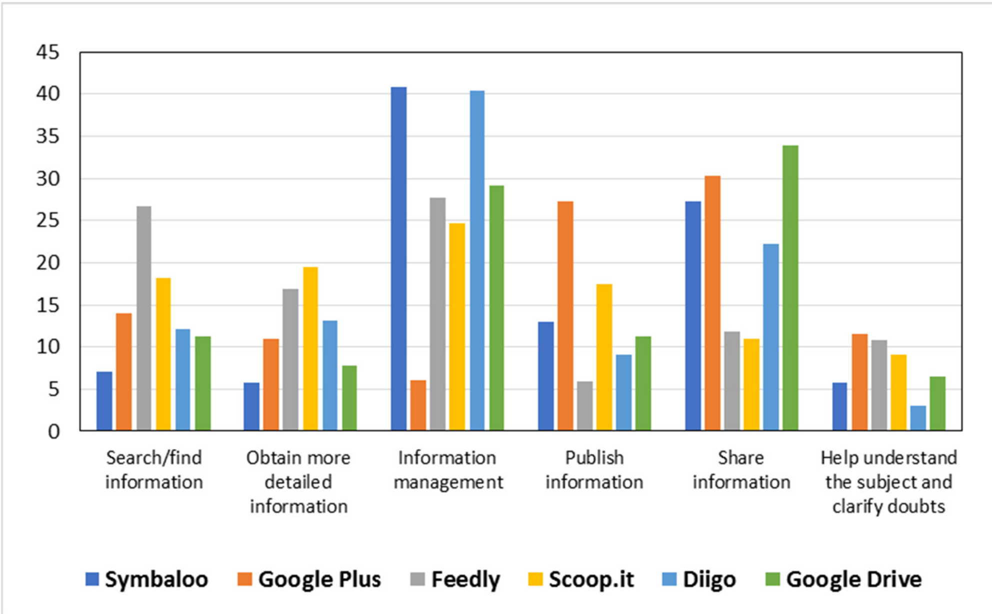

Figure 4. Uses of the digital tools.

We must highlight the encouragement of information management and organization skills through the tools included in Web 2.0 in which digital media are used, without the use of printed documents. The tools also encourage collaborative work because the information obtained is shared. Both aspects of these results show that the tools improve sustainable learning competences in the field of engineering, one of the fields included in STEM.

Furthermore, the tools could help the students understand the subject and clarify doubts. However, these are not uses of the proposed tools for PLE development, and, therefore, the corresponding score was not high. Nevertheless, this is an interesting result because it indicates that any digital tool focused on a specific topic for educational purposes can promote learning. This aspect could be linked to collaborative work. As the students are sharing more relevant information and contents with the group, they view the information that their classmates recommend. As the information shared is related to the topics of the subjects, the students study and deepen their knowledge of more relevant contents collaboratively. Thus, the tools help the students clarify doubts and improve their understanding of the subject.

The results of Questionnaire B (Appendix B) are shown in Table 1. The purpose of internet access is information searching, leisure, communication, work, training, social relations, and, finally, organization. Related to the way in which they organize information, the use of folders was highlighted compared to other tools. Recommendations by others (colleagues, friends, experts, etc.) give credibility to information, in contrast to being a trending topic on social networks. In relation to collaborative work, sharing, interacting, and building together were considered a priority. In addition, it was considered less important to divide the work and recombine it after. Students generally considered Drive as the most useful tool during the experience, and it was also the most used. Regarding the evaluation of the experience, the average score of the items was 3.5 out of 5, and in terms of their influence on the subject, the average evaluation was 3.28 out of 5.

4.3. Analysis of Factors and Relationships between Them

The results clearly showed the same relationships between the factors as in the example of IMO and UT. Questionnaire A (Appendix A) confirmed that the tools are useful for information management and organization. However, it would be interesting to evaluate the results of Questionnaire B (Appendix B) by searching for relationships between the factors. For that reason, we wanted to evaluate whether the utility of the tools (UT) could be related to collaborative work (CW). For this, the Pearson's linear correlation method (bivariate correlations) was used to verify relationships between the factors. Table 5 shows the values of the Pearson correlation coefficients.

Table 5. Pearson's correlation coefficients.

		UT	CW	IMO	CW
UT	Pearson's Correlation	1	0.337 **	-	-
	Sig. (bilateral)	-	0.005	-	-
CW	Pearson's Correlation	0.337 **	1	-	-
	Sig. (bilateral)	0.005	-	-	-
IMO	Pearson's Correlation	-	-	1	0.410 **
	Sig. (bilateral)	-	-	-	0.000
CW	Pearson's Correlation	-	-	0.410 **	1
	Sig. (bilateral)	-	-	0.000	-

** The correlation is statistically significant (Sig. (bilateral) $\leq$ 0.01).

As can be seen, there was a relatively significant relationship between UT and CW. Furthermore, the level of significance helped us reach this conclusion, although the mean value of the Pearson coefficient showed that the relationship between the factors was low (0.337). In the case of IMO and CW, a relatively significant relationship was observed between both factors. Again, the mean value of the Pearson's correlation coefficient measured the strength of the relationship (medium–low factor ratio: 0.410).

The analysis of the relationships between factors indicated that CW was also related to other factors included in the questionnaire. Such was the case of PIA and IC, as Table 6 shows.

Table 6. Pearson's correlation coefficients (CW vs. IC; CW vs. PIA).

		CW	IC	CW	PIA
CW	Pearson's Correlation	1	0.387 **	-	-
	Sig. (bilateral)	-	0.001	-	-
IC	Pearson's Correlation	0.387 **	1	-	-
	Sig. (bilateral)	0.001	-	-	-
CW	Pearson's Correlation	-	-	1	0.477 **
	Sig. (bilateral)	-	-	-	0.000
PIA	Pearson's Correlation	-	-	0.477 **	1
	Sig. (bilateral)	-	-	0.000	-

** The correlation is statistically significant (Sig. (bilateral) $\leq$ 0.01).

Finally, to evaluate the experience, the relationship between the activities (AC) and the subject results (SB) was analyzed. In this case, the Pearson's coefficients were calculated and the linear slope method was used (Table 7). Figure 5 shows the relationship between these two factors.

Table 7. Pearson's correlation coefficients (AC vs. SB).

		AC	SB
AC	Pearson's Correlation	1	0.855 **
	Sig. (bilateral)	-	0.002
SUB	Pearson's Correlation	0.855 **	1
	Sig. (bilateral)	0.002	-

** The correlation is statistically significant (Sig. (bilateral) $\leq$ 0.01).

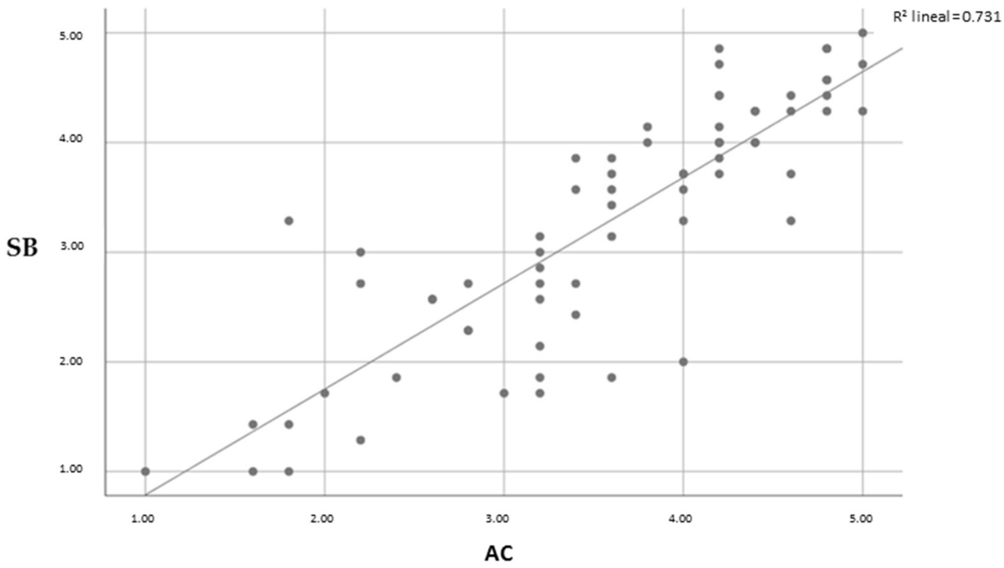

Figure 5. Correlation between Activities (AC) and Subject (SB).

There was a very significant relationship between both factors. Furthermore, the level of significance helped us to reach this conclusion. Therefore, the following hypothesis could be stated: the activities carried out (AC) have an impact on the results of the subject (SB).

4.4. Academic Results

The impact of the implementation of these activities on the academic performance of students was obtained through the analysis of academic results over a period of three academic years. Only the academic results of the subject "Power Electronics" were significant, because the contribution of the activities' mark to the final mark of the subject was 15%. The parameters used were the performance rate (number of passing students out of the total number of students enrolled, expressed as a percentage) and the success rate (percentage of passing students out of the number of students tested).

The academic results from the last three academic years of this subject showed an increase in the proportion of students tested from 42% to 72%. The performance rate increased from 38.7 to 68%, and the success rate increased from 92.3 to 94.4%. Although the activities require effort and time, they had a great influence on the learning of the specific topics of the subject.

5. Discussion

In the field of university education, the STEM area encompasses a variety of university degrees covering a wide range of occupations/career fields like medicine, telecommunications, and electronics, among others. In addition, new disciplines are currently emerging in response to industry and societal demands. The new STEM degrees are related to data processing (Big Data), virtual reality and augmented reality, the Internet of Things (IoT), bioinformatics, etc. All these topics are demanded by companies in the profiles of their employees.

We live in the information and technology era, and the demand for technical profiles has grown in recent years. These topics imply the management of a large amount of information and interactions in multidisciplinary and collaborative work environments. Companies increasingly need professionals linked to STEM careers who must feel motivated to pursue science and technology. For this purpose, the following skills or aptitudes are needed: analytical capacity; mathematical, scientific, and technical skills; creativity; and the ability to collaborate to develop teamwork, which allows work with other professionals, and to carry out a project.

In this experience, carried out in STEM degrees, students were in contact with advances in technology while working collaboratively. All of this is favored if the students construct, improve, and update their personal learning environments. On the other hand, it is important to link these technological advances with the objectives of sustainable learning, since they allow the development of competences that are applicable in all STEM areas.

The results of this experience indicate that the tools chosen and the way the students use them in the development of a PLE are clearly related to the objectives of sustainable learning.

In relation to information management and organization, the use of digital environments has many environmental benefits. Waste and emissions are reduced through a move from physical goods (papers, folders, storage areas, links, etc.) to digital tools and services, through efficient networks and equipment. In addition, the digital environment eliminates the spatial barrier; it is possible to work without sharing the same physical space, using applications such as video conferencing and virtual collaboration tools instead of physical travel. All of these factors have environmental benefits.

Another objective of sustainable learning is collaborative work, and this experience showed that the tools favor it. PLE development in groups of students implies additional efforts toward collaboration, consensus, adaptation, and integration between them with the objective of presenting a representative PLE for all the team. This experience favored collaborative work, enhancing cooperation and interaction between students with the same purpose, which was to learn about the topics of the subject.

Additionally, the results of this work show that there were relationships between collaborative work (CW) and other factors, such as the purpose of Internet access (PIA) and the credibility of the information (CI). In the case of PIA, the relationship can be clearly justified as a common and shared goal motivating students to come together and work collaboratively. On the other hand, if students work collaboratively, they share information and express their views. This way, they are creating links, professional ties, and interests among themselves through fluid and close communication. This experience takes account of the fact that it is possible to encourage integration, another sustainable learning objective.

The results of this experience indicate that PLEs can be used not only to develop specific teaching content for STEM subjects, but also as a vehicle for the acquisition of skills related to sustainable learning. On the other hand, the versatility of the PLEs makes it possible to use them in any other subject, as the competences related to sustainability are applicable to all subjects. In addition, they are necessary life-long skills for career development in STEM fields.

6. Conclusions

This work presented the use of digital tools for the generation of personalized learning environments in engineering subjects. This experience taught the students the concepts, the structure, and the necessary tools for the creation of a PLE for educational purposes. The students are now well acquainted with the new tools and they know how to use them. The creation of a PLE allows the achievement of learning linked to the contents of the curriculum and educational objectives. In addition, students developed digital skills which are very necessary for their future professional development in STEM areas in engineering studies.

Furthermore, in this experience, with the use of PLEs, sustainable learning objectives such as information management and organization, collaborative work, and integration were achieved.

This experience shows that PLEs can be used as a vehicle for the competences related to sustainability, since they are applicable in all degrees. In addition, as the experience followed a clear methodology, in future works, this experience can be replicated in other subjects.

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Appendix A. Questionnaire A: Tools

Demographic Data

Subject:

- ☐ Data Acquisition Systems
- ☐ Power Electronics
- ☐ Electronic Systems and Industrial Instrumentation

Gender:

- ☐ Male
- ☐ Female

Age:

- ☐ 18–19
- ☐ 20–21
- ☐ 22–23
- ☐ 24–25
- ☐ >25

Point out the advantages that the Symbaloo/Google Plus/Feedly/Scoopit/Diigo/Google Drive tool has for you:

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- ☐ Obtain more detailed information
- ☐ Information management
- ☐ Publish information
- ☐ Share information
- ☐ Help understand the subject and clarify doubts

* Note: The original questionnaire had a block of options for each tool.

Appendix B.

Appendix B.1. Questionnaire B: Activities, Experience, and Subject

Appendix B.1.1. Purpose of Internet Access (PIA)

Table A1. Mainly, for what purpose do you access the Internet?

	1	2	3	4	5	Not Used
Communication	☐	☐	☐	☐	☐	☐
Information	☐	☐	☐	☐	☐	☐
Work	☐	☐	☐	☐	☐	☐
Leisure	☐	☐	☐	☐	☐	☐
Organization	☐	☐	☐	☐	☐	☐
Training	☐	☐	☐	☐	☐	☐
Social Relations	☐	☐	☐	☐	☐	☐

5. Totally agree; 4. Agree; 3. Neither agree nor disagree; 2. Disagree; 1. Totally disagree; N: Not used.

Appendix B.1.2. Information Management and Organization (IMO)

Table A2. I prefer to organize and manage information with . . .

	1	2	3	4	5	Not Used
Folders	☐	☐	☐	☐	☐	☐
Social bookmarks (Diigo, Delicious...)	☐	☐	☐	☐	☐	☐
Wikis/Use blogs	☐	☐	☐	☐	☐	☐
Social networking tools (Twitter, Facebook...)	☐	☐	☐	☐	☐	☐

5. Always/almost always; 4. Often; 3. Sometimes; 2. Seldom; 1. Almost never; N: Not used.

Appendix B.1.3. Information Credibility (IC)

Table A3. What adds credibility to the information you receive?

	1	2	3	4	5	Not Used
Recommendation by my colleagues/friends	☐	☐	☐	☐	☐	☐
Social networks	☐	☐	☐	☐	☐	☐
Position in Google	☐	☐	☐	☐	☐	☐
It being a trending topic on Twitter	☐	☐	☐	☐	☐	☐
Finding it in several resources (articles, videos, web)	☐	☐	☐	☐	☐	☐
Recommendation by an expert	☐	☐	☐	☐	☐	☐

5. Always/almost always; 4. Often; 3. Sometimes; 2. Seldom; 1. Almost never; N: Not used.

Appendix B.1.4. Collaborative Work (CW)

Table A4. In teamwork, I prioritize . . .

	1	2	3	4	5	Not Used
Sharing resources	☐	☐	☐	☐	☐	☐
Interacting with others	☐	☐	☐	☐	☐	☐
Working together/coediting	☐	☐	☐	☐	☐	☐
Dividing the work among the group members and joining the parts once they are finished	☐	☐	☐	☐	☐	☐

5. Always/almost always; 4. Often; 3. Sometimes; 2. Seldom; 1. Almost never; N: Not used.

Appendix B.1.5. Utility of the Tools (UT)

Table A5. Evaluate the following tools according to the usefulness they have had for you, 5 being the most useful and 1 being the least (you can give the same value to several tools).

	1	2	3	4	5
Symbaloo	☐	☐	☐	☐	☐
Google Plus	☐	☐	☐	☐	☐
Feedly	☐	☐	☐	☐	☐
Scoop.it	☐	☐	☐	☐	☐
Diigo o Pocket	☐	☐	☐	☐	☐
Drive	☐	☐	☐	☐	☐

Appendix B.1.6. Evaluation of the Activities and Subject (AC and SB)

5. Strongly agree. 4. Agree. 3. Neither agree nor disagree. 2. Disagree. 1. Strongly disagree. N: Not used.

The teachers were involved in the activity.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The instructions of the activities were clear and explicit.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The time I spent on the PLE was adequate and compatible with the subject.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The PLEs were significant for learning in this subject.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

I consider that the activities have a positive impact.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

It would be interesting to participate in similar activities in other subjects.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The mark obtained for the activities was consistent with the difficulty/effort.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Working collaboratively was more motivating than working individually.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The effort and time spent were consistent with the results obtained.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

I think that this experience was good for managing learning content.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The experience improved my acquisition of digital skills.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

The performance of this activity allowed me to develop competences and skills that I consider to be important in my future profession.
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

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